Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 11(4): 1675, 12 June 2015 doi: http://dx.doi.org/10.15560/11.4.1675
ISSN 1809-127X © 2015 Check List and Authors

Range extension and natural history observations of a rare Panamanian snake, *Geophis bellus* Myers, 2003 (Colubridae: Dipsadinae)

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Abstract: The fossorial snake *Geophis bellus* is a small Panamanian endemic previously known only from the holotype. Here we report additional specimens, which greatly expand the known range of the species ca. 200 km from the type locality into western Panama. Furthermore, we provide information on sexual dimorphism in some scalation counts and in body and tail size. Finally, we provide information on natural history, including activity period, habitat usage, and reproductive cycle. Such discoveries are important for the development of conservation plans for this species in Panamá.

Key words: Coclé, Colón, Panama, sexual dimorphism, reproduction, Veraguas

Detailed knowledge about the distribution of most species of snakes in the genus *Geophis* remains limited due to their fossorial habits, rendering them difficult to find. The genus has a broad distribution from Mexico to the western slopes of the Colombian Andes (Myers 2003). To date, 49 species have been described and seven occur in Panama (Wilson and Townsend 2007; Köhler 2008; Jaramillo et al. 2010; Pavón-Vásquez et al. 2011; Pavón-Vásquez et al. 2013). Among the Panamanian species is *Geophis bellus* Myers, 2003, a small, rare snake characterized mainly by its dark color, both on the dorsum and venter, and a white nuchal band.

The holotype is a male collected in the cloud forests that encompasses Cerro Jefe, in the Serranía Piedras-Pacora, Parque Nacional Chagres (PNCh; 09°15′ N, 079°22′ W; designated by a star on Figure 1), to the east of the Panama Canal in Panamá province (Myers 2003). This is the only specimen of *Geophis bellus* collected prior to our work, and surprisingly, was found in 1964, 39 years prior to its description. Kilburn et al. (2011) noted that they swabbed an individual from "El Copé" for the presence of *Batrachochytrium dendrobatidis*, but no specimen or photographic voucher of the individual is available for evaluation. In their paper, "El Copé" refers to the area of Parque Nacional General de División Omar Torrijos Herrera (PNGDOTH; Locality 4 on Figure 1) north of the community El Copé, which is located in Coclé province (V. Kilburn, pers. comm.).

Given the single specimen of this species that has been studied, any variation in morphology and most of its ecology and other life history traits are unknown. Here, we describe additional specimens of *Geophis bellus*, extend the geographical range, and discuss morphological, ecological, and reproductive aspects for the species.

Specimens were collected in national parks and one unprotected area on both the eastern and western sides of the Panama Canal. On the eastern side, we visited both versants of Cerro Bruja, with the northern portion located in Parque Nacional Portebelo (PNP) and the southern portion in PNCh, both in Colón province. On the western side of the Canal we visited PNGDOTH in Coclé province, Parque Nacional Santa Fe (PNSF) in Veraguas province, and the town of El Valle de Antón in Coclé province.

Eight specimens of *Geophis bellus* were encountered while conducting herpetological surveys at various sites in central and western Panama. Five individuals were collected, euthanized, and fixed in 10% formalin and preserved in 70% ethanol. One individual escaped before it could be measured or photographed and two were photographed, but not measured or sexed.

Ambient temperature and relative humidity (RH)

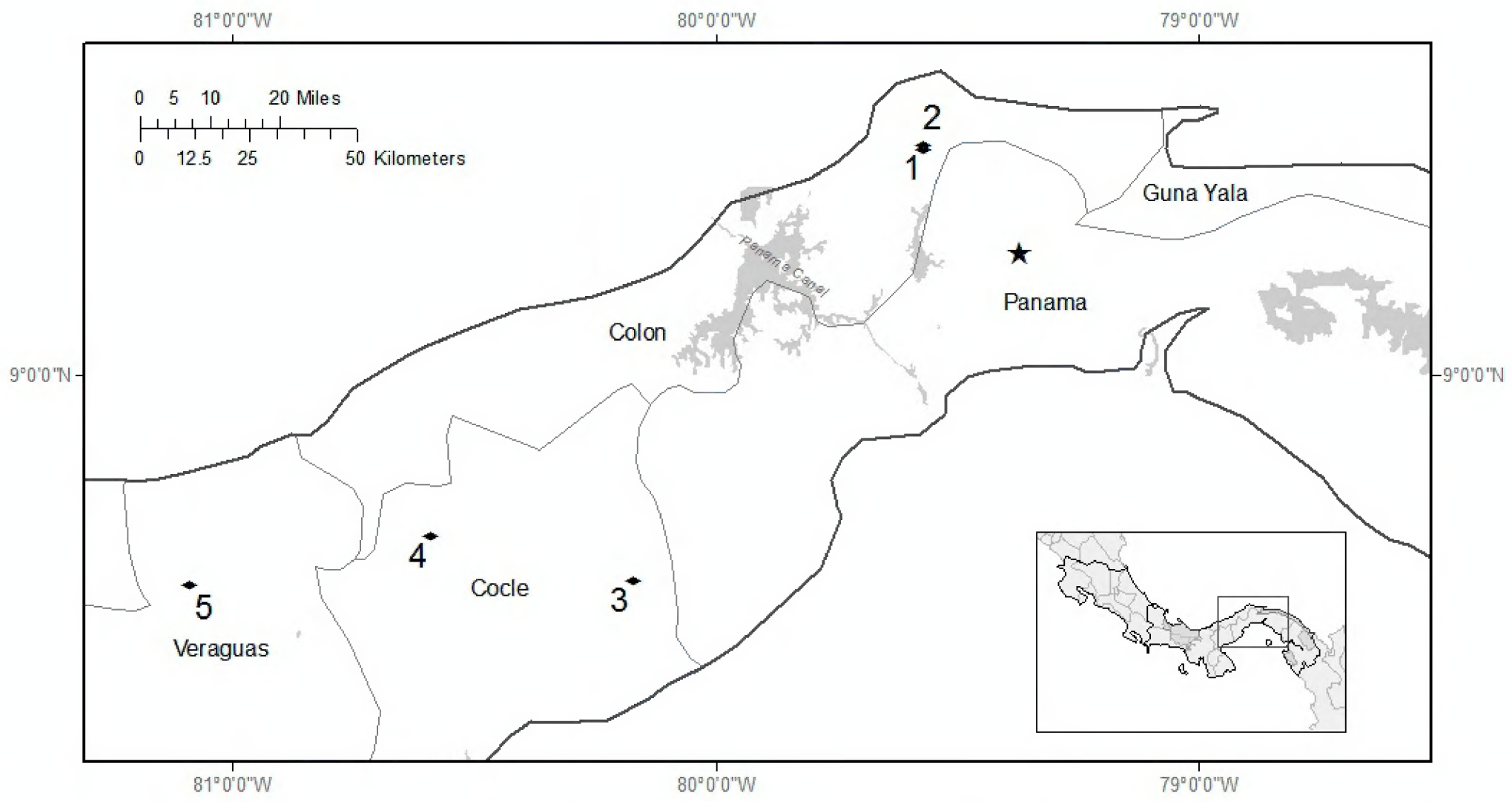

Figure 1. Map of specimens of *Geophis bellus* included in this paper. Star designates the holotype (Myers 2003) and other localities match those discussed in this paper.

were measured at point of capture. GPS coordinates are all WGS84. Snout-vent length (SVL) and tail length (TL) were measured in mm. We calculated TL/SVL ratio by dividing tail length by snout-vent length.

Collection permits (SE/A 51-13, SE/A 53-13, SC/A 5-13) were issued by Autoridad Nacional del Ambiente (ANAM). Preserved specimens were deposited in the Museo de Vertebrados of the Universidad de Panamá (MVUP), Círculo Herpetológico de Panamá (CHP), or currently are held in El Copé de La Pintada (Table 1). Photographs of individuals that were not preserved, in addition to any photographs used in this paper of preserved animals, were digitally vouchered in the University of Texas – Arlington [USA] Digital Catalog (UTADC).

On 20 October 2009 at 20:28 h AS, E. Toribio and D. Natera found a *Geophis bellus* (UTADC 8066; Figure 2A) on the Camino del Macho de Monte in Bajo del Palmar, El Pantano, PNSF, Veraguas province (08°34′12″ N, 081°05′ 24″ E, 1100 m above sea level [a.s.l.]; Locality 5 on Figure 1). This is a range extension of ca. 201 km southeast into Veraguas province from the type locality. The area where the snake was collected is primary cloud

Figure 2. Photographs of various specimens of *Geophis bellus* included in this paper. **A:** UTADC 8066 from Parque Nacional Santa Fe, Veraguas province, **B:** MVUP-2135; Parque Nacional Portobelo, Province of Colón, **C:** UTADC 8085 from El Valle de Antón, Coclé province, **D:** MVUP-2136 in PNGDOTH, Coclé province, **E:** JMR931/UTADC 8069, in PNGDOTH, Coclé province, **F:** JMR937/UTADC 8068, in PNGDOTH, Province of Coclé, **G:** CH-9805; UTADC 8067 in Parque Nacional Chagres, Colón province.

Table 1. Measurements and scale counts (when available) for *Geophis bellus*, including the holotype (Myers 2003) and specimens documented in this paper. SVL = snout-vent length in mm, TL = tail length in mm, R= TL/SVL ratio, D = dorsal scale rows at anterior-midbody-posterior, V = ventrals, SC = subcaudals, SL = supralabials, and IL = infralabials.

ID	Locality	Sex	SVL	TL	R	D	V	SC	SL	IL	Notes
KU 110703	Cerro Azul	M	201	32	0.16	15-15-15	131	33	6	7	Holotype
JMR 931	PNGDOTH	M	210	33	0.16	15-15-15	127	28	6	7	
JMR 937	PNGDOTH	M	215	37	0.17	15-15-15	135	29	6	7	
MVUP 2136	PNGDOTH	F	231	22.5	0.09	16-17-16	141	24	6	7	Gravid
MVUP 2135	PNP	F	132	21.5	0.16	16-15-16	145	34	6	7	
CH 9805	PNCh	M	182	32	0.17	15-15-15	128	31	6	7	

forest with a relatively open understory below trees that reach ca. 10 m in height and were filled with epiphytes. The snake was found crawling in the leaf litter. It was photographed and released but not measured or sexed.

On 22 July 2011 at ca. 11:30 h., LEL collected a female specimen (MVUP-2135; Figure 2B) from the top of Cerro Bruja, PNP, Región del Alto Chagres, Colón province (09°28′ N, 079°33′ W; 975 m a.s.l.; Locality 2 on Figure 1). This is a range extension of ca. 27 km from the type locality to the northwest into Colón province. The snake was found on the ground near a surveying trail during a cloudy day with 89% RH and 22.7°C ambient temperature. The site is composed of mature and pristine cloud forest located on the Atlantic versant and is part of the Panama Canal watershed. The forest is characterized by abundant epiphytes and canopy heights of ca. 10 m. The snake measured 132 mm SVL and 21.5 mm TL (0.16 TL/SVL ratio). This individual was the shortest one we found and has dorsal scale rows 15-16-16, ventrals 145, subcaudals 34 paired, supralabials 6 and infralabials 7, and an undivided cloacal scute (Table 1).

In January 2010, after dark, J. Wedow and M. Urriola found an individual (UTADC 8085) under a piece of trash in El Valle de Antón, in far eastern Coclé province (08°34′ N, 080°10′ W, Locality 3 in Figure 1). This is a range extension of ca. 105 km from the type locality southwest into Coclé province The individual was photographed (Figure 2C) and released, but not sexed or measured.

On 17 September 2012 at 21:45 h, LEL collected a female (MVUP-2136, Figure 2D) in PNGDOTH, near El Copé de La Pintada, Coclé province, Panama (08°40′ N, 080°37′ W); elevation not recorded; Locality 4 in Figure 1). This is a range extension of ca. 145 km southwest from the type locality. The snake was found after a light rain that increased RH to ca. 100%; the ambient temperature was 20.1°C. The habitat consisted of a mature riparian forest with abundant mosses, ferns, and epiphytes on rocks and branches of trees overhanging the stream. The forest canopy was ca. 23 m high and trees were covered mostly by epiphytes. The stream was ca. 2.5 m wide with some pools and large rocks in its course. The snake measured 231 mm SVL and 22.5 mm TL (0.09 TL/SVL ratio). This was the longest individual we found and had dorsal scale rows 16-17-16, ventrals 142, subcaudals 24 paired, supralabials 6, infralabials 7, and an undivided cloacal scute (Table 1). This specimen was gravid when collected, and two days after collection a white egg of ca. 22 mm × 8 mm was laid. The snake was then euthanized and preserved. In the process it was damaged, but revealed that the female had just the one egg that had been laid; no additional eggs remained in her body.

On 18 June 2013, after dark, R. A. Pyron and F. T. Burbrink found a male individual (field number JMR931 and UTADC 8069; Figure 2E) moving through the leaf litter in PNGDOTH (08°40′ N, 080°37′ W; ca. 760 m elevation; Locality 4 on Figure 1). This is a range extension of ca. 145 km southwest from the type locality. This individual measured 210 mm SVL and 33 mm TL (0.16 TL/SVL ratio) and weighed 5.5 g. The individual had dorsal scale rows 15-15-15, ventrals 127, subcaudals 28 paired, supralabials 6 and infralabials 7, and an undivided cloacal scute (Table 1).

Two nights later, on 20 June 2013 after dark, R. A. Pyron found a second male individual (JMR937, UTADC 8068; Figure 2F) moving through the leaf litter near Quebrada La Ranita (TADS Project's "Loop Stream;" Ray 2009) in PNGDOTH (08°40′ N, 080°37′ W; 760 m a.s.l.; Locality 4 on Figure 1). This is a range extension of ca. 145 km southwest from the type locality. The area is mature secondary cloud forest (cut > 40 years ago). This individual measured 215 mm SVL and 37 TL (0.17 TL/SVL ratio) and weighed 6.0 g. The individual had dorsal scale rowss 15-15-15, ventrals 135, subcaudals 29 paired, supralabials 6, infralabials 7, and an undivided cloacal scute (Table 1).

On 22 July 2013 AS, J. de la Cruz, and K. Ramos found two individuals on Cerro Bruja, PNP, Distrito de Portobelo, Colón province (09°27′ N, 079°34′ W; 700 m a.s.l.; Locality 1 in Figure 1). This is a range extension of ca. 27 km from the type locality to the northwest into Colón province. The two individuals were found along a transect in the forest. The first individual was found at 20:45 h crawling in the leaf litter with an ambient temperature of 22°C and relative humidity of 89%. This individual was captured but escaped before photographs were taken or the specimen could be measured. The second individual is male and was found crawling in

the leaf litter at 22:23 h with an ambient temperature of 22°C and relative humidity of 89%. It was collected and deposited in the CHP (CH-9805; UTADC 8067; Figure 2G). This individual measured 182 mm SVL and 32 TL (0.17 TL/SVL ratio) and has dorsal scale rows 15-15-15, ventrals 128, subcaudals 31 paired, supralabials 6, infralabials 7, and an undivided cloacal scute (Table 1).

All individuals had the characteristic black dorsum and venter with a white nuchal band, as in the holotype (Myers 2003; Figure 2A–2G).

Initially, *Geophis bellus* was known only from one specimen found east of the Panama Canal in Panamá province (Myers 2003). Based on our material and considering Kilburn et al. (2011), we demonstrate herein that *Geophis bellus* occurs in cloud forests in Colón province on the Caribbean versant near the type locality, and unexpectedly, in central Coclé and Veraguas provinces west of the Panama Canal. This is an expansion of the known range to the west by over 200 km, with individuals found in the middle.

When comparing the morphological data of our specimens of *G. bellus* we did not find variation in the number of supra- or infralabial scales between or within the sexes (Table 1). However, even considering our relatively small sample size, we did find that females have more dorsal scale rows and ventrals than males (Table 1). Also, the largest male we found (JMR 937) has 135 ventrals, while the smallest female (MVUP 2135) has 145 ventrals (Table 1). In addition, females have shorter tails; the shortest tail of the males (both KU 110703 and CH9805) is 32 mm, while the largest tail of a female is only 22.5 mm. TL within females or males is not variable despite differences in SVL, although there is little increase in TL relative to SVL in males (Table 1). Surprisingly, the TL/SVL ratio is similar between the males and the smallest female, but decreased substantially for the largest gravid female (Table 1). These data suggest that there may be sexual dimorphism in body size and tail length that could be the result of the characteristic pattern of species of snakes where reproduction is more expensive for females (Madsen and Shine 1994; Shine 1994). However, given our small sample size, measurements of additional specimens are needed to confirm any patterns that are suggested here. Moreover, we did notice variation in the extent of the white nuchal collar among the specimens (Figure 2A–G), but are unsure of the significance of such differences. Finally, nothing morphological suggests that the populations on the east vs. west sides of the Canal are different, but molecular studies would confirm such.

Our data also suggest that *G. bellus* may be a generalist species in terms of temporal activity and habitat use. Most of the individuals that we collected were found active at night. However, one individual (MVUP-2135) was active at midday. Also, we found two individuals near streams, in contrast to the others found relatively far away from water. The fact that one individual from PNGDOTH (MVUP-2136) laid an egg highlights the oviparous reproductive mode of *G. bellus*, its gravity period during the second half of year, and a minimum clutch size.

Geophis bellus is categorized as an endemic species of Panama, and as a consequence of its previously highly restricted range, is listed as Vulnerable by the IUCN (Jaramillo et al. 2010). Fortunately, most all of the localities where we found individuals are within protected areas of the Sistema Nacional de Areas Protegidas (SINAP) managed by the Panamanian government. Also, all of the protected areas, except PNCh, are under the umbrella of the Corredor Biológico Mesoamericano del Atlántico Panameño (CBMAP), an initiative of ANAM that promotes conservation for protected areas on the Atlantic versant at a regional level (Muschett and Polanco 2006). Furthermore, PNP and PNCh are included in the cluster of protected areas that make up La Región del Alto Chagres, important in supplying the water for domestic and industrial use in Panamá and Colón provinces, including the functioning of the Panama Canal (Candanedo and Samudio 2005). Thus, habitat loss, which may be the most real threat to these small snakes, is reduced to a minimum, considering the strength of SINAP to prevent deforestation.

We now know that *Geophis bellus* has a wide national range from eastern Panamá and Colón provinces to western Veraguas province, albeit restricted to mid-elevation cloud forest. Furthermore, there is variation in scalation and size between males and females that might be driven by reproductive pressures. Long-term population monitoring is required for a better understanding the ecological and reproductive aspects necessary for successful conservation of *G. bellus*.

ACKNOWLEDGEMENTS

The field trips to Cerro Bruja were possible with funding from Fundación Parque Nacional Chagres as part of the monitoring program for Región del Alto Chagres directed by Sociedad Mastozoológica de Panama. PNGDOTH was visited by LE thanks to CBMAP and ANAM. J. Añino provided invaluable field assistance. F.T. Burbrink, R.A. Pyron, M. Urriola, and J. Wedow secured additional specimens. We thank L.D. Wilson, R. MacCulloch, and one anonymous reviewer for comments that significantly improved the manuscript.

LITERATURE CITED

Candanedo. I. and R. Samudio. 2005. Construyendo un Mecanismo para Medir el Éxito de
la Conservación en el Alto Chagres. TNC-ANCON. Panamá, Panamá. 80 pp.

Jaramillo, C., L.D. Wilson, R. Ibáñez and F. Jaramillo. 2010. The Herpetofauna of Panama: Distribution and Conservation Status;

pp. 604–671, in: L.D. Wilson, J.H. Townsend, and J.D. Johnson (eds.). Conservation of Mesoamerican amphibians and reptiles. Eagle Mountain: Eagle Mountain Publishing.

Kilburn, V.L., R. Ibáñez and D.M. Green. 2011. Reptiles as potential vectors and hosts of the amphibian pathogen *Batrachochytrium dendrobatidis* in Panama. Diseases of Aquatic Organisms 97:127–134. doi: 10.3354/da002409

Köhler, G. 2008. Reptiles of Central America. 2nd edition. Offenbach, Germany: Herpeton Verlag. 400 pp.

Madsen, T. and R. Shine. 1994. Costs of reproduction influence the evolution of sexual size dimorphism in snakes. Evolution 48(4): 1389–1397.

Muschett, G. and J. Polanco. 2006. Áreas importantes para la conservación de especies globalmente amenazadas en Panamá. Informe final. ANCON, CI. 56 pp.

Myers, C.W. 2003. Rare snakes — Five new species from eastern Panama: reviews of northern *Atractus* and southern *Geophis* (Colubridae: Dipsadinae). American Museum Novitates 3391:1–47. doi: 10.1206/0003-0082(2003)391<0001:RSFNSF>2.0.CO;2

Pavón-Vázquez, C.J., U.O. García-Vázquez, J.C. Blancas-Hernández and A. Nieto-Montes de Oca. 2011. A new species of the *Geophis sieboldi* group (Squamata: Colubridae) exhibiting color pattern polymorphism from Guerrero, Mexico. Herpetologica 67(3): 332–343. doi: 10.1655/HERPETOLOGICA-D-11-00003.1

Pavón-Vázquez, C.J.; L. Canseco-Márquez and A. Nieto-Montes de Oca. 2013. A new species in the *Geophis dubius* group (Squamata: Colubridae) from northern Puebla, México. Herpetologica 69 (3): 358–370.

Shine, R. 1994. Sexual size dimorphism in snakes revisited. Copeia 1994(2): 326–346. http://www.jstor.org/stable/1446982

Wilson, L.D. and J.H. Townsend. 2007. A checklist and key to the snakes of the genus *Geophis* (Squamata: Colubridae: Dipsadinae), with commentary on distribution and conservation. Lista y clave de las serpientes del género *Geophis* (Squamata: Colubridae: Dipsadinae) con comentarios sobre la distribución y conservación. Zootaxa 1395:1–31.

Authors' contribution statement: LEL, AS, and JMR collected data, PR made the map, LEL, AS, and JMR wrote the text, LEL, AS, JMR, and PR reviewed and edited the manuscript, JMR checked the English in the text.

Received: 20 October 2014
Accepted: 27 May 2015
Academic editor: Ross MacCulloch